International Journal of Agricultural
Science and Research (IJASR)
ISSN(P): 2250-0057; ISSN(E): 2321-0087
Vol. 7, Issue 2, Apr 2017, 289-296

STUDIES ON STANDARD HETEROSIS OF SINGLE CROSSES OF TROPICAL WHITE MAIZE FOR GRAIN YIELD AND YIELD CONTRIBUTING TRAITS

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ABSTRACT

In Ghana, low yields of 1.7 t ha^{-1} has been reported .This prominent difference in grain yields has been attributed partially to the use of open pollinated varieties (OPVs), shortage of high yielding varieties, biotic and abiotic stresses. Thus, the present study was designed to estimate the magnitude of heterosis of the single crosses over checks for yield and yield-contributing characters. A line x tester mating design involving sixteen white maize inbred lines as females and two testers as males generated thirty-two single crosses. These hybrids and three checks were evaluated using a 5 x 7 alpha lattice design replicated twice at the University of Ghana, WACCI research farm during 2015/-16 offseason using drip irrigation. Heterotic effects were observed for grain yield, days to 50% anthesis, days to 50% silking, anthesis-silking interval, plant height, husk cover , ear height, maize streak virus, plant aspect, ear length, ear rot, number of kernel rows ear^{-1} and number of kernels row^{-1}, however the magnitude varied with characters. From this study hybrids L8 x T2, L1 x T2, L16 x T1, L16 x T2 L4 x T2, L9 x T1 exhibited 54%, 45%, 41% 26%, 24% and 24% heterosis for grain yield respectively, over best check Obatanpa.

KEYWORDS: ***Heterosis, Line x Tester, Maize, Yield***

Received: Jan 27, 2017; **Accepted:** Feb 28, 2017; **Published:** Mar 14, 2017; **Paper Id.:** IJASRAPR201740

INTRODUCTION

In maize, inbred lines are low yielding while hybrids exhibit high degree of heterosis for yield as well as other agronomic traits (Adebayo *et al*., 2013; Ali *et al.*, 2012, Silva *et al.*, *2003*).

Therefore, heterosis is a display of the genetic difference among genotypes. When heterosis or some of its components are significant for all traits, it can be concluded that there is genetic diversity among the genetic materials.

Maize breeders, therefore, know that the chance of getting a highly heterotic hybrid is high when the crosses are between distant lines (Gomes *et al*., 1995). Therefore, the superiority of maize hybrid varieties for grain yield highly depends on the magnitude of heterosis expressed in their hybrids.

MATERIAL AND METHODS

Description of Experimental Area

The experiment was carried out during 2015/16 offseason using drip irrigation at, West Africa Centre for Crop Improvement research field, University of Ghana. The University is located at 5.6508^0 N, latitude and 0.1869^0W longitude and an altitude 97 meter above sea level (m.a.s.l).

Genetic Materials Used for the Study

Eighteen white tropical maize inbred lines with diverse genetic backgrounds were selected from the pool of inbred lines at the West Africa Centre for Crop Improvement (WACCI). This comprises of ten lines from the International Institute for Tropical Agriculture (IITA), six from International Maize and Wheat improvement Center (CIMMYT) and the two testers 1368 from IITA and CML 444 from CIMMYT maize breeding programmes. The 16 inbred lines were crossed to the two testers using the line by tester method and it generated 32 (16 x 2) cross combinations.

Standard Heterosis

To evaluate the performance of hybrids, computation for heterosis for all recorded traits that showed significant differences among genotypes was carried out as percentage increase or decrease of the cross performance over the standard checks using the following formula (Falconer, 1996)

$$\text{Standard Heterosis} = \frac{F_1 - SV}{SV} \times 100$$

Where,

F_1 = Mean performance of a cross

SV = Mean performance of the standard check variety

Test of significant for percent heterosis was made using the t-test. The standard errors of the difference for heterosis and t-value were computed as:

$$t\ (\text{standard cross}) = \frac{F_1 - SV}{SE\ (d)}$$

$$SE\ (d) = (2Me/r)^{1/2}$$

Where, SE (d) = standard error of the difference

Me = error mean square

r = number of replications

The computed t value tested against the t-value at degree of freedom for error.

Estimation of Standard Heterosis of Crosses for Yield and Yield Contributing Traits

Standard heterosis over the three standard checks was computed for grain yield and other traits whose genotypes mean square were significant. The results showed considerable amount of heterosis over the standard checks. Heterotic effects were observed for grain yield, days to 50% anthesis, days to 50% silking, anthesis-silking interval, plant height, husk cover , ear height, maize streak virus, plant aspect, ear length, ear rot, number of kernel rows ear^{-1} and number of kernels row^{-1}, however the magnitude varied with characters (Table 1, Table 2, Table 3 and Table 4)

The positive and high heterosis observed for grain yield of some of the testcrosses indicated that the crosses perform better than the checks and this translates to higher yield. These hybrids (L8 x T2, L1 xT2, L16 x T1, L16 x T2, L4

x T2 and L9 x T1) with high heterosis were identified as potential candidate to increase the productivity of maize for the consumers. This finding is in agreement with the previous work reported by several researchers (Abrha, 2014; Ali *et al*., 2014; Kumar *et al.*, 2014) who found promising crosses over checks based on their mean performance and heterosis effect.

Estimates of heterosis for plant height revealed positive and negative standard heterosis over the checks 1368 x CML 444 and Mamaba. On the other hand, all testcrosses manifested negative heterosis over check Obatanpa. Negative heterosis for plant height is desirable which indicates the existence of crosses, which can make selection effective to reduce stem lodging. Similarly, estimation of heterosis for ear height showed both negative and positive heterosis over the check 1368 x CML 444. On the other hand, all crosses in the study showed negative heterosis over Obatanpa and nine of the crosses exhibited significant and negative heterosis over Obatanpa whereas five crosses recorded positive standard heterosis for this trait. Negative heterosis for ear height is desirable which indicates the existence of crosses, which can make selection effective to reduce stem lodging. This investigation is in conformity with the previous reports (Abrha *et al.*, 2014; Kumar *et al*., 2014) who found negative and positive standard heterosis for these traits.

Negative heterosis observed in L8 x T2 (-49), L4 x T2 (-22) and L16 x T1 (-22) over Mamaba, L8 x T2 , L7 x T1 and L11 x T2 over Obatanpa is an indication that the hybrids performed better than the checks in terms of their response to maize streak virus (MSV) disease. However none of the crosses had significant heterosis effects over the hybrid check 1368 x CML 444.

Estimates of heterosis for days to 50% anthesis revealed both negative and positive standard heterosis over the Obatanpa and Mamaba. Heterosis of testcrosses over the two checks Obatanpa and Mamaba had the same magnitude and varied from -5 (L8 x T1, L8 x T2) to 7. However, there were no significant heterotsis effects over the hybrid check between the two testers (1368 x CML 444). Similarly, heterosis for days to 50% silking showed negative heterotic effect for nine testcrosses over Obatanpa and Mamaba. On the contrary, L3 x T1 demonstrated positive and significant heterosis over the two checks. Negative heterosis is desirable for days to 50% anthesis and silking as it indicates earliness of hybrids to maturity. Heterosis effect for anthesis-silking interval over check of hybrid between the two testers exhibited significant and negative standard heterosis for L3 x T2 and L15 x T2. Among 32 crosses tested, 19 crosses revealed significant negative heterosis percentage than Obatanpa. It implies that most of the crosses had fewer days for anthesis-silking interval than Obatanpa, indicating that there was no good synchronization between anthesis and silking for these crosses (Wang *et al*., 2007).

Heterosis effects for plant aspect revealed both negative and positive effect over the hybrid between the two testers (1368 x CML444) while negative heterosic effects were observed over Obatanpa for all 32 testcrosses. Similarly, heterosis over Mamaba observed 28 crosses with negative heterosis over this check. Negative heterosis effects indicate that crosses were good at plant aspect compared to the checks.

Heterosis for husk cover**:** except L1 x T1, all crosses exhibited significant negative heterosis which varied from -1000 to 73.21 over the hybrid check between two testers. Three testcrosses recorded significant and positive standard heterosis over Obatanpa indicating that these crosses had worse husk cover than the check. However, heterosis of husk cover over Mamaba revealed significant negative and positive husk cover. The negative heterosis implies that the testcrosses' cobs had a good husk cover while the positive heterosis indicates that those testcrosses had poor husk cover when compared to the check. Heterosis for ear rot revealed both negative and positive heterosis effects. Among the 32 crosses, twenty-seven testcrosses manifested negative standard heterosis over the hybrid between the two testers, indicating

the testcrosses were better than the hybrid between the two checks for this trait. Thus, the 27 testcrosses included in the study will be used for future breeding to overcome the problem of ear rots. Among 32 crosses, 23 testcrosses showed significant and positive heterosis effect over check Obatanpa and none of the testcrosses showed negative heterosis indicating that Obatanpa was better than the crosses included under the study. Heterosis over the commercial hybrid check Mamaba no significant differences except L13 x T2. In general, the standard heterosis of testcrosses under study was not better than the two commercial checks for this particular trait.

The magnitude of heterosis percentage for ear length showed positive and negative heterosis over the hybrid check between two testers and Obatanpa. Of the 32 crosses, nine crosses had significant positive standard heterosis over the two checks. Similarly, heterosis percentage estimates for testcrosses over standard hybrid check Mamaba showed five hybrids giving significant and positive standard heterosis. Thus, positive significant heterosis for this trait leads bigger ears, which can contributed to yields. Heterotic effects for number of kernel rows ear^{-1} were shown by nine crosses, which gave negative and significant heterosis over the hybrid between the two testers. However, none of the crosses showed positive standard heterosis for this trait. Standard heterosis over Obatanpa was shown by six crosses which had significant and positive heterosis percentage. On the contrary, only L16 x T2 exhibited positive standard heterosis over Mamaba.

Estimates of heterosis for number of kernels row^{-1}:- showed that the hybrid between the two testers and Obatanpa had the same magnitude. Of the 32 crosses, three testcrosses manifested significant positive heterosis effects in the desired direction over the two checks. Similarly, heterosis over Mamaba calculated for L4 x T2 and L12 x T2 showed positive and significant heterosis. In general, crosses with long ear, high numbers of kernel rows ear^{-1} and high numbers of kernels row^{-1} are important to increase grain yield of maize. This finding is in agreement with several researchers' investigations (Abrha, 2014; Amiruzzaman et al., 2010; Ali *et al.*, 2014; Kumar *et al.*, 2014) who found both negative and positive standard heterosis over checks for these traits.

ACKNOWLEDGMENTS

The first author is grateful to the scholarship awarded from Crop Scientist for African Agriculture (CSAA) project. A special thanks to Mr. Amos Rutherford Azinu and the field workers at West African for Crop Improvement Centre for the support rendered during field evaluation

CONCLUSIONS AND RECOMMENDATIONS

Six promising testcrosses (L8 x T2, L1 x T2, L16 x T1, L16 x T2, L4 x T2 and L9 x T2) which had higher yield compared to the checks were identified based on their standard heterosis of grain yield. Therefore, these top testcrosses with high standard heterosis identified in this study should be used in maize research the programme as possible candidates for release after confirming the stability of their performance in multi-locations and one more season. Testcrosses revealed negative and significant heterotic effect for MSV disease should be used in future maize breeding programme to overcome MSV disease problem.

Table 1: Estimation of Standard Heterosis of Crosses for Grain Yield, Plant Height and Maize Streak Disease Over 1368 X CML444, Obatanpa and Mamaba

	1368 x cml444			Obatanpa			Mamaba		
Crosses	**Yld**	**PH**	**MSD**	**Yld**	**PH**	**MSD**	**Yld**	**PH**	**MSD**
L1 x T1	18	18***	8	9	-18***	-2	18	8*	-25**
L1 x T2	57***	-0.3	10	45**	-31***	-0.15	57***	-9*	-24*
L2 x T1	27*	13**	-4	17	-21***	-13.1	27*	4	-34***
L2 x T2	32*	3	4	22	-28***	-5.7	32*	-6	-28*
L3 x T1	-17	-5	4	-23*	-34***	-5.7	-16	-13**	-28*
L3 x T2	29*	6	2	19	-27***	-7.54	29*	-3	-30**
L4 x T1	10	15***	-4	2	-20***	-13.1	10	5	-34***
L4 x T2	34**	10**	14	24.*	-23***	3.55	35**	1	-21*
L5 x T1	23	17***	-2	13	-19***	-11.2	23	7	-32***
L5 x T2	30*	16***	-14	21	-20***	-22.3	31*	6	-41***
L6 x T1	13	5	6	4	-27***	-3.85	13	-4	-27*
L6 x T2	4	-6	8	-4	-35***	-2	4	-14***	-25*
L7 x T1	29*	2	-24	20	-29***	-31.6*	30*	-7	-48***
L7 x T2	20	-4	-6.	11	-33***	-14.9	20	-12**	-35***
L8 x T1	6	5	-6	-2	-27***	-14.9	6	-4	-35***
L8 x T2	66***	12**	-26	56***	-22***	-33.4**	67***	2	-49***
L9 x T1	34**	5	-8	24*	-27***	-16.8	34**	-4	-37***
L9 x T2	23	9*	-14	13	-25***	-22.3	23	-1	-41***
L10 x T1	-6	-14**	12	-13	-40***	1.7	-6	-21***	-23*
L10 x T2	-2	0.1	10	-9	-35***	-0.15	-2	-8*	-24*
L11 x T1	6	16***	-4	-2	-20***	-13.1	12	6	-34***
L11 x T2	27*	14**	-20	17	-21***	-27.9*	27*	4	-30***
L12 x T1	13	1	10	4	-30***	-0.15	13	-8*	-24*
L12 x T2	17	11*	-10	8	-23***	-18.6	17	1	-38***
L13 x T1	28*	17***	-14	18	-19***	-22.3	28*	7	-41***
L13 x T2	29*	5	-10	19	-27***	-18.6	29*	-4	-38***
L14 x T1	-25*	-2	8	-35**	-32***	-2	-30*	-10**	-25**
L14 x T2	26*	13**	10	16	-21***	-0.15	26*	4	-24*
L15 x T1	31*	19***	-2	21	-18***	-11.2	31*	9*	-32**
L15 x T2	28*	-2	35*	18	-32***	22.04	28*	-11*	-7
L16 x T1	53***	9	14	41***	-25***	3.55	53***	-1	-21*
L16 x T2	36**	7	-10	26*	-26***	-18.6	37**	-2	-24*
SE (d)	**466**	**6**	**0.41**	**466**	**6**	**0.41**	**466**	**6**	**0.4**

*, ** and **** = P ≤ 0.05, P ≤ 0.01 and P ≤ 0.001, respectively

Yld = grain yield, PH = plant height and MSD = maize streak disease

Table 2: Estimation of Standard Heterosis for Yield Related Traits Studied Over 1368 X CML444

Crosses	AD	SD	ASI	EH	PLASP	HC %	E Rot %	NKRE
L1 x T1	0	0	50	30.97**	16.67	73.21**	-40.61	-18.75**
L1 x T2	1.75	0	-50	35.48***	-16.67	-46.43	-58.30	-6.25
L2 x T1	0	-1.64	0	30.65**	0	-87.50**	-92.36**	0
L2 x T2	0	-1.64	-50	22.74**	-33.33*	-94.64**	-92.84**	0
L3 x T1	3.51	0.82	-50	-16.29	33.33*	-16.07	-67.23*	-6.25
L3 x T2	1.75	-1.64	-100.0**	30.81**	-16.67	-87.50**	-74.52*	-6.25
L4 x T1	-1.75	-3.29**	0	29.19**	-16.67	-87.50**	-78.76*	-18.75**
L4 x T2	0	-1.64	0	18.55*	-16.67	-64.29*	-92.85**	-6.25
L5 x T1	-5.26	-4.93***	0	11.13	16.67	-83.93**	-92.84**	0
L5 x T2	-3.51	-4.93***	-50	25.48**	0	-76.79**	-95.75**	-12.5
L6 x T1	-3.51	-4.11***	50	10.81	16.67	-100.00***	-100.00**	-31.25***
L6 x T2	-3.51	-1.64	50	-4.68	0	-83.93**	-73.67*	-18.75**
L7 x T1	-1.75	-3.29**	0	13.06	0	-87.50**	-96.18**	-12.5
L7 x T2	1.75	-0.82	-50	3.55	0	-82.14**	-100.00**	-12.5

Table 2: Contd.,								
L8 x T1	-8.77	-8.22***	0	6.29	0	-100.00***	-95.41**	-25.00**
L8 x T2	-8.77	-9.86***	-50	33.87***	-66.67***	-94.64**	-100.00**	-12.5
L9 x T1	-5.26	-6.58***	-50	9.84	0	-64.29*	-92.83**	-6.25
L9 x T2	-1.75	-4.11***	-50	27.10**	-16.67	-94.64**	-95.01**	-6.25
L10 x T1	0	-1.64	-50	-15.16	33.33*	-41.07	-62.41	-25.00**
L10 x T2	0	-2.47*	-50	12.58	33.33*	-100.00***	-87.31*	-12.5
L11 x T1	-3.51	-4.11***	0	2.42	16.67	-83.93**	-96.84**	0
L11 x T2	-3.51	-4.93***	-50	23.71**	-33.33*	-83.93**	-85.31*	-12.5
L12 x T1	0	-2.47*	-50	11.77	-16.67	-100.00***	-88.26*	- 31.25***
L12 x T2	0	-2.47*	-50	27.10**	-33.33*	-69.64**	-71.02*	-12.5
L13 x T1	0	-1.64	-50	34.52***	16.67	-41.07	-67.31	-6.25
L13 x T2	0	-1.64	-50	19.19*	0	37.5	29.97	-12.5
L14 x T1	0	-0.82	-25	-8.39	16.67	-33.93	-77.61*	-18.75**
L14 x T2	-1.75	-3.29**	0	17.42	16.67	-46.43	-82.36*	0
L15 x T1	-5.26	-7.407	-50	16.77	16.67	-87.50**	-84.08*	-6.25
L15 x T2	1.75	-1.64	-75.0*	7.1	33.33*	-76.79**	-74.52*	-25.00**
L16 x T1	0	-0.82	0	25.65**	0	-94.64**	-100.00**	-6.25
L16 x T2	-1.75	-2.47*	0	35.81***	-33.33*	-89.29**	-87.56*	12.5
SE (d)	**0.75**	**0.62**	**0.66**	**5.48**	**0.46**	**7.38**	**7.34**	**1.02**

*, ** and *** $p \leq 0.05$, $P \leq 0.01$ and $P \leq 0.001$, respectively.

AD = days to 50% anthesis, SD = days to 50% anthesis, ASI = anthesis- silking interval, EH = ear height, PlASp = plant aspect, HC% = husk cover percentage, E rot = ear rot percentage and NKRE = number of kernel rows ear^{-1}

Table 3: Estimation of Standard Heterosis for Yield Contributing Traits over Obatanpa

Cross	AD	ASI	EH	PLASP	HC %	E rot %	EL	NKRE	
L1 x T1	3.6**	0	-18.1**	-12.5	506.3***	1518.3***	10	0	
L1 x T2	5.5***	-66.7**	-15.2**	-37.5**	87.5	1036.4***	20.0***	15.4	6.1
L2 x T1	3.6**	-33.3	-18.3**	-25*	-56.3	108.3**	3.3	23.1*	4.6
L2 x T2	3.6**	-66.7**	-23.2***	-50***	-81.3	95.1**	13.3*	23.08*	7.6
L3 x T1	7.3***	-66.7**	-47.6***	0	193.8*	792.9***	-10	15.4	-18.2**
L3 x T2	5.5***	-100***	-18.2**	-37.5**	-56.3	594.4***	0	15.4	-3.0
L4 x T1	1.8	-33.3	-19.2**	-37.5**	-56.25	478.7***	-13.33*	0	-18.2**
L4 x T2	3.6**	-33.3	-25.8***	-37.5**	25	94.8**	20.0***	15.4	21.2**
L5 x T1	-1.8	-33.3	-30.5***	-12.5	-43.8	95.1**	6.7	23.1*	12.1
L5 x T2	0	-66.7**	-21.5***	-25*	-18.8	15.8	13.33*	7.7	13.6*
L6 x T1	0	0	-30.7***	-12.5	-100	-100	3.33	-15.4	1.5
L6 x T2	0	0	-40.4***	-25*	-43.8	617.4***	3.33	0	-4.6
L7 x T1	1.82	-33.33	-29.26***	-25*	-56.3	4.2	3.33	7.69	3.03
L7 x T2	5.45***	-66.67**	-35.22***	-25*	-37.5	-100	6.67	7.69	9.09
L8 x T1	-5.5***	-33.33	-33.5***	-25*	-100	25	-6.67	-7.69	3.03
L8 x T2	-5.5***	-66.67**	-16.25**	-75***	-81.3	-100	10	7.69	-15.15*
L9 x T1	-1.82	-66.67**	-31.28***	-25*	25	95.3**	0	15.38	1.52
L9 x T2	1.82	-66.67**	-20.48***	-37.5**	-81.3	35.9	3.33	15.38	-21.21**
L10 x T1	3.64**	-66.67**	-46.92***	0	106.3	924.3***	-3.33	-7.69	-1.52
L10 x T2	3.64**	-66.67**	-29.57***	0	-100	245.8***	-26.7***	7.69	-27.27***
L11 x T1	0	-33.33	-35.92***	-12.5	-43.8	-13.9	0	23.08*	0
L11 x T2	0	-66.67**	-22.6***	-50***	-43.8	300.4***	-33.3***	7.69	-60.61***
L12 x T1	3.64**	-66.67**	-30.07***	-37.5**	-100	219.9***	26.67***	-15.38	21.21**
L12 x T2	3.64**	-66.67**	-20.48**	-50***	6.3	689.8***	26.67***	7.69	10.61
L13 x T1	3.64**	-66.67**	-15.84**	-12.5	106.3	790.7***	-6.67	15.38	-9.09
L13 x T2	3.64**	-66.67**	-25.43***	-25*	381.3***	3441.7***	20.00***	7.69	7.58
L14 x T1	3.64**	-50*	-42.68***	-12.5	131.3	510.1***	-6.67	0	-15.15*
L14 x T2	1.82	-33.33	-26.54***	-12.5	87.5	380.8***	6.67	23.08*	0
L15 x T1	-1.82	-66.67**	-26.94***	-12.5	-56.3	333.9***	-16.67**	15.38	-9.09
L15 x T2	5.45***	-83.3***	-33***	0	-18.8	594.4***	13.33*	-7.69	13.64*
L16 x T1	3.64**	-33.33	-21.39**	-25*	-81.3	-100	3.33	15.38	7.58
L16 x T2	1.82	-33.33	-15.04*	-50***	-62.5	238.9***	13.33*	38.46***	-12.12
SE (d)	**0.75**	**0.66**	**5.48**	**0.46**	**7.38**	**7.34**	**0.82**	**1.02**	**2.17**

*, ** and *** = $p \leq 0.05$, $P \leq 0.01$ and $P \leq 0.001$, respectively

AD = days to 50% anthesis, ASI = anthesis-silking interval, PLASP =plant aspect, HC% = husk cover in percent, E rot% = era rot in percent, EL = ear length, NKRE = number of kernel rows ear^{-1} and NKR = number of kernels row^{-1}

Table 4: Estimation of Standard Heterosis for Grain Yield Contributing Trait over Mamaba

Cross	SD	ASI	EH	PLASP	HC%	E rot %	EL	NKRE	NKR
L1 x T1	1.72	-25	16.33*	-22.22*	223.33***	65.98	3.13	-1.96	11.76
L1 x T2	1.72	-75.00**	20.34*	-44.4***	0	16.55	12.50*	0	2.94
L2 x T1	0	-50.00*	16.05*	-33.33**	-76.67	-78.63	-3.13	0.98	1.47
L2 x T2	0	-75.00**	9.03	-55.6***	-90	-79.99	6.25	0.98	4.41
L3 x T1	2.59*	-75.00**	-25.6**	-11.1	56.67	-8.42	-15.63*	0	-20.59*
L3 x T2	0	-100.0***	16.19*	-44.4***	-76.67	-28.78	-6.25	0	-5.88
L4 x T1	-1.72	-50.00*	14.76	-44.4***	-76.67	-40.65	-18.8**	-1.96	-20.59*
L4 x T2	0	-50.00*	5.3	-44.4***	-33.33	-80.03	12.50*	0	17.65*
L5 x T1	-3.45**	-50.00*	-1.29	-22.22*	-70	-79.99	0	0.98	8.82
L5 x T2	-3.45**	-75.00**	11.46	-33.33**	-56.67	-88.13	6.25	-0.98	10.29
L6 x T1	-2.59*	-25	-1.58	-22.22*	-100.00*	-100	-3.13	-3.92**	-1.47
L6 x T2	0	-25	-15.33	-33.33**	-70	-26.42	-3.13	-1.96	-7.35
L7 x T1	-1.72	-50.00*	0.43	-33.33**	-76.67	-89.31	-3.13	-0.98	0
L7 x T2	0.86	-75.00**	-8.02	-33.33**	-66.67	-100	0	-0.98	5.88
L8 x T1	-6.90**	-50.00*	-5.59	-33.33**	-100.00*	-87.18	-12.50*	-2.94*	0
L8 x T2	-8.6***	-75.00**	18.91*	-77.8***	-90	-100	3.13	-0.98	11.76
L9 x T1	-5.1***	-75.00**	-2.44	-33.33**	-33.33	-79.97	-6.25	0	-1.47
L9 x T2	-2.59*	-75.00**	12.89	-44.4***	-90	-86.06	-3.13	0	-23.5**
L10 x T1	0	-75.00**	-24.6**	-11.11	10	5.06	-9.38	-2.94*	-4.41
L10 x T2	-0.86	-75.00**	0	-11.11	-100.00*	-64.54	-31.3***	-0.98	-29.4***
L11 x T1	-2.59*	-50.00*	-9.03	-22.22*	-70	-91.17	-6.25	0.98	-2.94
L11 x T2	-3.45**	-75.00**	9.89	-55.6***	-70	-58.93	-37.5***	-0.98	-61.7***
L12 x T1	-0.86	-75.00**	-0.72	-44.4***	-100.00*	-67.19	18.75**	-3.92**	17.65*
L12 x T2	-0.86	-75.00**	12.89	-55.6***	-43.33	-18.99	18.75**	-0.98	7.35
L13 x T1	0	-75.00**	19.48*	-22.22*	10	-8.65	-12.50*	0	-11.76
L13 x T2	0	-75.00**	5.87	-33.33**	156.67**	263.3**	12.50*	-0.98	4.41
L14 x T1	0.86	-62.50**	-18.62*	-22.22*	23.33	-37.42	-12.50*	-1.96	-17.65*
L14 x T2	-1.72	-50.00*	4.3	-22.22*	0	-50.69	0	0.98	-2.94
L15 x T1	-6.0***	-75.00**	3.72	-22.22*	-76.67	-55.49	-21.8**	0	-11.76
L15 x T2	0	-87.5***	-4.87	-11.11	-56.67	-28.78	6.25	-2.94*	10.29
L16 x T1	0.86	-50.0*	11.6	-33.33**	-90	-100	-3.13	0	4.41
L16 x T2	-0.86	-50.0*	20.60*	-55.56**	-80	-65.24	6.25	2.94*	-14.71
SE (d)	0.62	0.66	5.48	0.46	7.38	7.34	0.82	1.02	2.17

*, ** and *** = $P \leq 0.05$, $P \leq 0.01$ and $P \leq 0.001$, respectively

SD = days to 50% silking, ASI = Anthesis-silking interval, PLASP = plant aspect, EH = ear height, HC% = husk cover in percent, EL = ear length, E rot % = ear rot in percent, NKRE = number of kernel rows ear^{-1}

REFERENCES

1. *Abrha SW. (2014). Standard Heterosis of Maize (Zea mays L .) Inbred Lines for Grain Yield and Yield Related Traits in Central Rift Valley of Ethiopia. Journal of Biology, Agriculture and Healthcare, 4(23), 31–38.*
2. *Adebayo MA, Menkir A, Blay E, Gracen V and Danquah EY. (2013). Performance of testcross maize hybrids of adapted and exotic inbred lines for grain yield and drought tolerance. African Crop Science Society, 11(20), 475–481.*
3. *Ali A, Rhman HU, Shah L, Shah KA, Rehman S. (2014). Heterosis for grain yield and its attributing components in maize variety Azam using line × tester analysis method. Academia Journal of Agricultrual Research, 2(November), 225–230.*
4. *Ali F, Shah IA, Rahman HU, Noor M, Durrishahwar, Khan MY, Ullah I and Yan J. (2012). Heterosis for yield and agronomic*

attributes in diverse maize germplasm. Australian Journal of Crop Science, 6(3), 455–462.

5. *Amiruzzaman M, Islam MA, Hassan L and Rohman MM. (2010). Combining Ability and Heterosis for Yield and Component Characters in Maize. Academic Jouranal of Plant Sciences, 3(2), 79–84.*
6. *Falconer D and Mackay T. (1996). introduction to quantitative genetics. 4th ed. Longman, London. longman.*
7. *Gama EG, Hallauer A R , Ferrao RG and Barbosa DM. (1995). Heterosis in maize single graphical analysis. Sarhad Journal of Agriicultre, 26(3), 373–379.*
8. *Kumar GP, Prashanth Y, Reddy VN, Kumar SS and Rao PV. (2014). Heterosis for Grain yield and its Component traits in Maize (Zea mays L .). International Pure and Applied Bioscience, 2(1), 106–111.*
9. *Wang Y, Cui Y, Zhang L, Li J, Li J, and Wang R. (2007). Effects of Syncronization between silk rececptive and pollen vigor on kernel sets of corn (Zea Mays L.). Frontiers If Agricultre in China, 1(3), 271.*
10. *Silva RM da, Branco J and Filho DM. (2003). Heterosis expression in crosses between maize populations: early yield, 1912, 519–524.*